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A Study of Aluminium Zinc Indium Thermal Spray Coatings for the Protection of Steel Rebars in Reinforced Concrete

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Background

- Steel reinforcement, or 'rebars' are extensively used in concrete structures but are susceptible to corrosion attack, leading to cracking and spalling of the concrete.
- Mitigation measures include modifying the internal environment in the concrete (e.g. chloride extraction), adopting cathodic protection, creating a barrier between the reinforcement and the concrete (i.e. coating the reinforcement) or using more corrosion resistant materials for the rebars[1].
- A metallic, thermally sprayed coating, on the concrete surface can form a protective barrier, whilst also cathodically protecting the rebars, provided an electrical connection is made to the coating.
- The benefits of this method include the ability to deposit a diverse range of thick (up to around 500 μm) coatings which can also be repaired in-situ[2] (figure 1).

Project Objectives

- Determine the ability of thermally sprayed Al-Zn-In coatings to sacrificially protect steel rebars in a chloride environment.
- Investigate the effect of surface finish on the bond strength of the coatings after exposure.

Figure 1 Photograph Showing Application of a Thermal Spray Coating to a Concrete Structure

(Photo courtesy Metallisation Ltd)

Experimental Procedure

Concrete Blocks

Concrete blocks measuring 170 x 170 x 55 mm were cast[3] with one of three surface finishes:

- Steel mould finish
- U4 float finish in accordance with MCHW 1[4]
- Grit blasted finish to BS EN 1766[5]

Coatings

Commercially available aluminium zinc indium coatings (composition given in table 1) were applied by arc spraying.

Coatings with a nominal thickness of 200 and 350 μm were applied for comparison.

	Zinc	Indium	Aluminium
Composition (wt%)	4.5-5.5	0.02-0.05	Remainder

Table 1 Nominal Composition of Al-Zn-In Coating

Testing

The ability of the coatings to sacrificially protect steel rebars was studied by measuring the corrosion current using a zero resistance ammeter (ZRA). The experimental arrangement is shown in figure 2. A 1:1 anode-cathode ratio was used.

After 2 weeks exposure to 5% w/v sodium chloride solution, the adhesion of the coatings was determined by pull-off tests using 50 mm diameter dollies attached to the surface (figure 3). A minimum of two tests was performed on each sample.

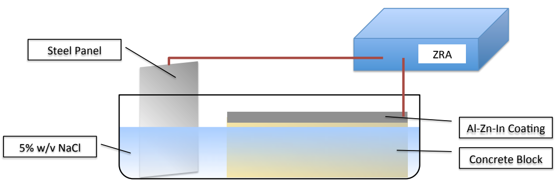

Figure 2 Schematic Showing Experimental Arrangement Used for Zero Resistance Ammetry Testing

Figure 3 Photographs Showing Pull-off Bond Tests

Results

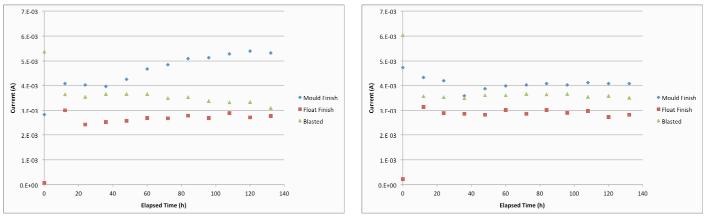

Figure 3 Corrsion Current Data for (a) 200 micron and (b) 350 micron Al-Zn-In Coatings in 5% w/v NaCl

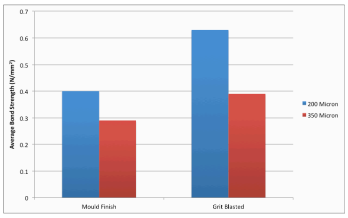

Figure 4 Al-Zn-In Coating Average Bond Strength Data After 2 Weeks Exposure in 5% w/v NaCl

Conclusions

- Thermally sprayed Al-Zn-In coatings are able to cathodically protect steel rebars.
- Post-exposure coating adhesion is better on grit blasted surfaces.
- Increasing coating thickness has a negative effect on bond strength.

Further Work

- Further ZRA tests and pull-off bond tests of different coatings thicknesses and surface finishes.
- Depolarization tests in chloride solution.
- Comparative trials with pure aluminium coatings.

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3. Design Manual for Road and Bridges, Waterproofing and Surfacing on Concrete Bridge Decks, BD 47/99
4. Manual of Contract Documents for Highway Works, Volume 1 Specification for Highway Works
5. BS EN 1766:2000 Products and systems for the protection and repair of concrete structures - Test methods - Reference concrete for testing

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